JC

RESTRICTED CIRCULATION

This paper is not an official document; it is for information only and must not be quoted in any printed publication.

AGRICULTURAL MEMORANDUM NO 952

M N Hough

Simulation of Cereal Growth - further work on temperature and respiration.

Memorandum no 921 presented some results of simulations based on data for Sutton Bonington winter wheat crops from 1974 to 1977. In that memorandum comment was made that low temperatures in spring might restrict photosynthesis and that high respiration losses at the end of the growth cycle were due to the unrealistic assumption that all the dry weight respires. This memorandum makes some attempt to correct these faults and the new results are compared with the previous ones.

Temperature

The modification of photosynthesis rate by temperature was based upon Monteith (1981). When the mean daylight temperature for a week is above 10°C it is assumed that there is no response to temperature and photosynthesis is maximum. When the mean daylight temperature, T was between 0°C and 10°C photosynthesis was reduced by a factor T/10. For temperatures below 0°C photosynthesis is zero. T is calculated from

$$T=(TMAX + TMIN)/2 + 0.21(TMAX - TMIN)/2$$

Respiration

Two ideas were tested. The first is to assume that maintenance respiration declines when the leaf area index declines after the peak near anthesis. If the peak leaf area index is LMAX and L is the index some time after, then the maintenance respiration R is multiplied by a factor L/LMAX. There is no basis in the literature for this. [Respiration model 1].

The second method is to use Austin (1982). Austin quotes several reports that respiration during the grain filling phase from anthesis to death is 40% of gross assimilate. Anthesis occurs at the time when leaf area is maximum and from that time total respiration loss is calculated as above. Note that there is no separation into synthesis and maintenance after anthesis. [Respiration model 2].

Results

The results for 1974-1977 for winter wheat at Sutton Bonington are in the graphs.

1974

In April and May, agreement is only slightly better when temperature is taken into account because the weather was not very cold. Respiration model 1 produces a curve with small gradients in mid July when the actual crop was still growing rapidly. Model 2 gives a higher yield, but the gradients are much more like the observed crop.

1975

The temperature modification produces a lower growth rate in April with the gradient closer to the observed gradient. Respiration model 2 gives more yield than model 1 and grows much quicker in late June and July than either the observed crop, or model 1.

1976

The 'no nitrogen' treatment is shown. Calculations were begun in early February and the temperature factor has made a large improvement in the fit, even to the extent of getting the 'bend' in the curve in late March/early April. Respiration model 2 gives the higher yields, but the gradients agree better with the observed gradients than do those of model 1.

1977

The observed crop grew very slowly in spring and not even the temperature modification improves the fit very well. Respiration model 1 produced very slow growth in July whereas model 2 agreed better with the observations.

Discussion

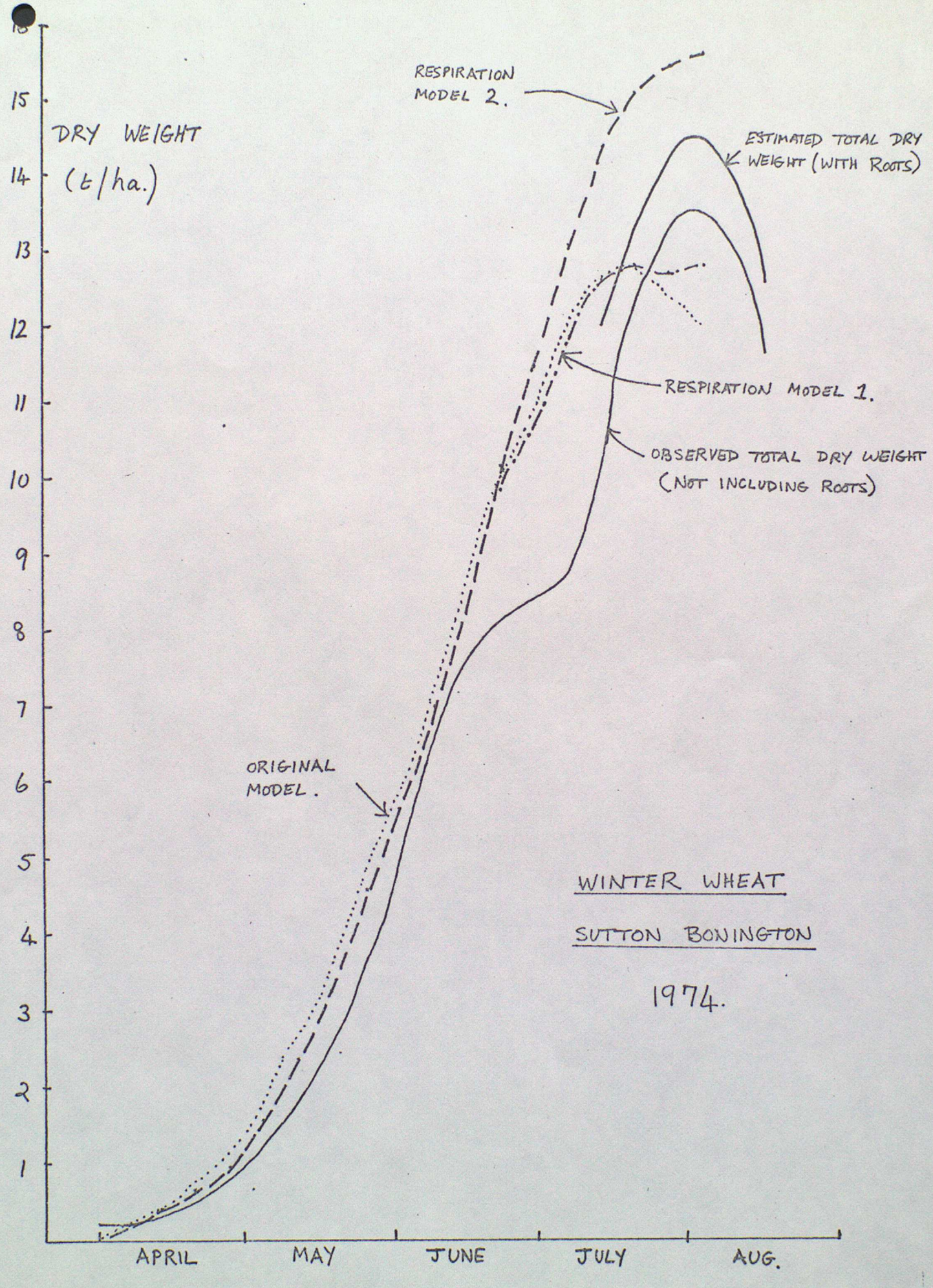
The temperature modifications to photosynthesis in spring produced a small improvement in each year, and a marked improvement in one year when temperatures were below 10°C for several months. However in spring, the observed growth was usually less than the calculated growth. This is probably due to a lower maximum photosynthesis rate of leaves which grow in winter/early spring, compared to the rate used in the model. There do not seem to be any reports of photosynthesis rates in the literature, for crops in winter.

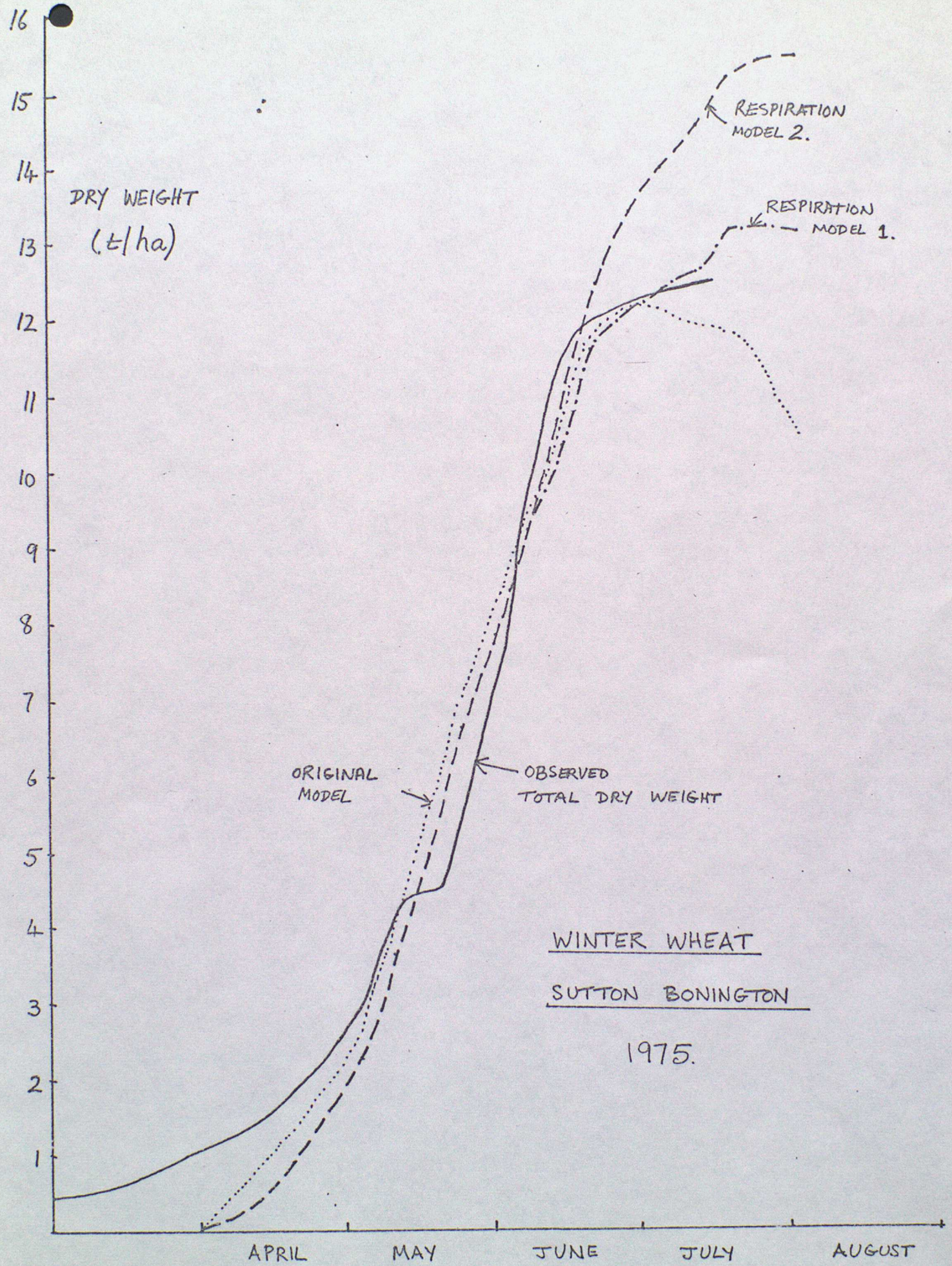
Both of the respiration models improved the shape of the dry weight curve in July. The large fall in dry weight observed with the original model is now absent. However, model 1 tended to produce very small growth rates in mid July when the observations indicated rapid growth. Model2 (which is taken from the literature) exhibits growth rates in July much more in agreement with observations, although final DM yields are 2-4 t/ha higher.

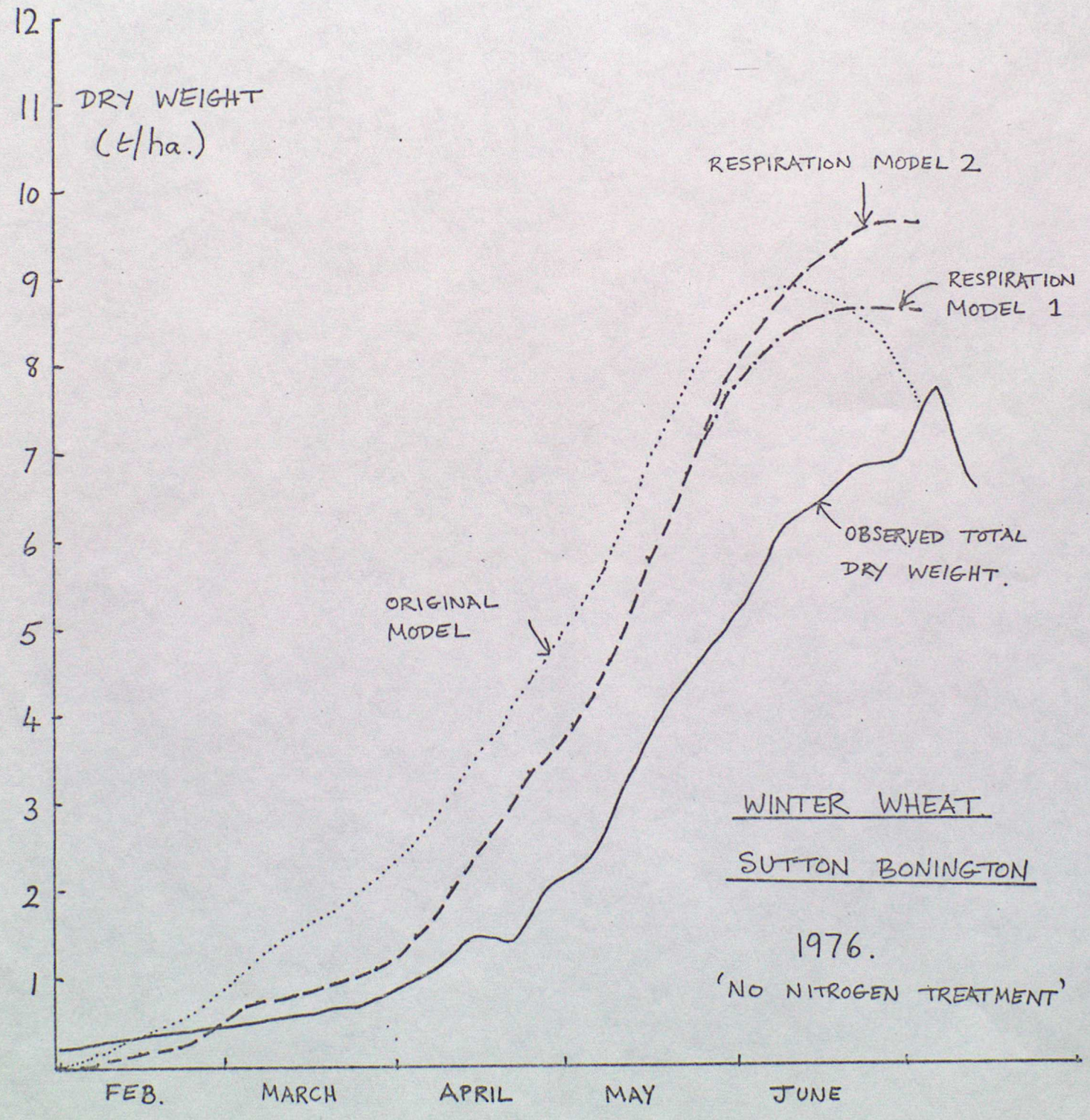
Meteorological Office
Harrogate
August 1982

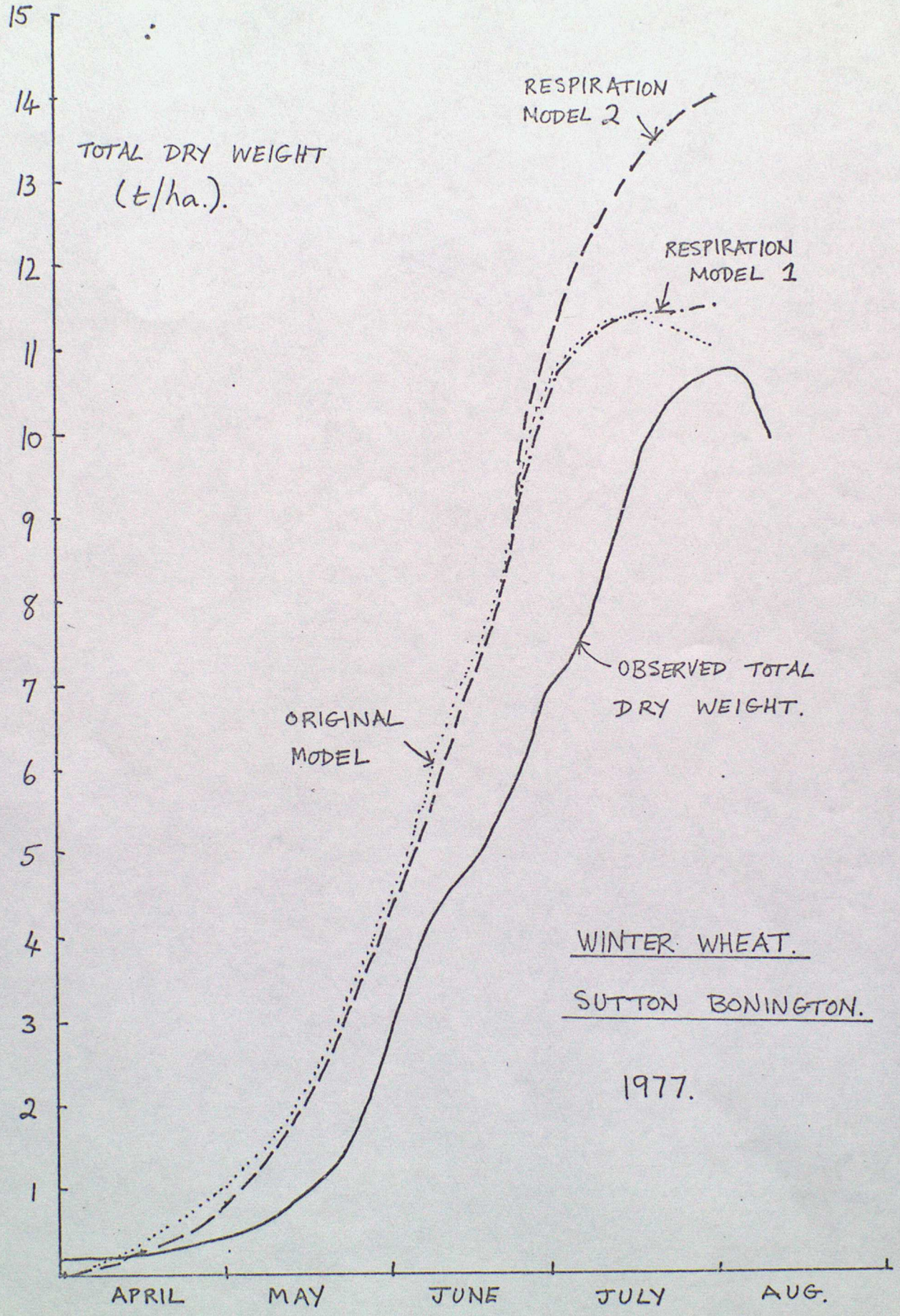
Austin, R.B. 1982 Crop characteristics and the potential yield of wheat. J. agric. Sci, 98, 447-453.

Monteith, J.L. 1981 Does light limit crop production? Chapter 2 in 'Physiological Processes limiting plant productivity' C.B. Johnson ed. Butterworths, London.


DRY WEIGHT
(t/ha.)
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
RESPIRATION MODEL 2.
ESTIMATED TOTAL DRY WEIGHT (WITH ROOTS)
RESPIRATION MODEL 1.
OBSERVED TOTAL DRY WEIGHT (NOT INCLUDING ROOTS)
ORIGINAL MODEL.
WINTER WHEAT
SUTTON BONINGTON
1974.
APRIL
MAY
JUNE
JULY
AUG.


16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
DRY WEIGHT
(t/ha)
RESPIRATION
MODEL 2.
RESPIRATION
MODEL 1.
ORIGINAL
MODEL
OBSERVED
TOTAL DRY WEIGHT
WINTER WHEAT
SUTTON BONINGTON
1975.
APRIL
MAY
JUNE
JULY
AUGUST


12
11
10
9
8
7
6
5
4
3
2
1
DRY WEIGHT
(t/ha.)
RESPIRATION MODEL 2
RESPIRATION
MODEL 1
OBSERVED TOTAL
DRY WEIGHT.
ORIGINAL
MODEL
WINTER WHEAT.
SUTTON BONINGTON
1976.
'NO NITROGEN TREATMENT'
FEB.
MARCH
APRIL
MAY
JUNE


15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
TOTAL DRY WEIGHT
(t/ha.).
RESPIRATION
MODEL 2
RESPIRATION
MODEL 1
ORIGINAL
MODEL
OBSERVED TOTAL
DRY WEIGHT.
APRIL
MAY
JUNE
JULY
AUG.
WINTER WHEAT.
SUTTON BONINGTON.
1977.